INTRODUCTION TO
ANIMAL BREEDING

Lecture Nr 4

The efficiency of selection
The selection programmes

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The genetic gain and its parameters

Comparison of the different selection methods

The multiple trait selection

Selection programmes

Summary
From one generation to the other

Candidates

Choice of the parents at random

Offspring

No genetic change

E. Verrier, Introduction to Animal Breeding, Hanoi, December 2004
Representation of a selection step

Candidates

Selection of the parents

Offspring of the selected animals

$\Delta G$

Change in EBV $\rightarrow$ Genetic gain

E. Verrier, Introduction to Animal Breeding, Hanoi, December 2004
Parameters of the genetic gain

1) The genetic variance of the trait

More progress is expected within Population Nr 1 than within Population Nr 2
Parameters of the genetic gain

2) The selection criterion

Corrélation between the selection criterion and the genetic value

Selection criterion = EBV  \rightarrow  R = [Rep]^{1/2}
Parameters of the genetic gain

3) The selection pressure

Selection intensity:

\[ i = \text{standardised differential} = \frac{S}{\text{EBVs standard deviation}} \]

\[ p = \frac{\text{No Selected}}{\text{No candidates}} \]

Chapter IV, Figure 10 and Table 11

E. Verrier, Introduction to Animal Breeding, Hanoi, December 2004
Parameters of the genetic gain

4) The duration of the process

From one generation to the other: Generation interval

\[ T = \text{Average age difference between parents and offspring} \]
Prediction of the annual genetic gain

\[
E(\Delta Ga ) = \frac{i R \sigma_A}{T}
\]

Accuracy of selection = Square root of the repeatability of EBVs

Selection Intensity

Additive genetic standard deviation

Generation Interval
The genetic gain and its parameters

Comparison of the different selection methods

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Summary
Mass selection
- individual selection, phenotypic selection -

<table>
<thead>
<tr>
<th>Own Performance</th>
<th>$i$</th>
<th>$R$</th>
<th>$T$</th>
</tr>
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<tbody>
<tr>
<td>+++++</td>
<td>+ + / -</td>
<td>+ + / -</td>
<td></td>
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</table>

Main advantages:
Easiness, low cost → May be applied to large numbers of animals

Limits:
Traits for which performances exist in a single sex
Traits to be measured after slaughtering of the animal

Conclusion:
Sometimes sufficient, but often to be complemented with other methods
Pedigree selection

**Performances (EBVs) of parents**

<table>
<thead>
<tr>
<th>i</th>
<th>R</th>
<th>T</th>
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<tr>
<td>-</td>
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**Main advantages:**
Earlyness (mating to procreate the next candidates)

**Limits:**
Low accuracy
Interest of the parents but little value of the far ancestors

**Conclusion:**
Necessary for a first selection, always to be complemented
Progeny testing

Average performance of a small sample of offspring

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<thead>
<tr>
<th></th>
<th>i</th>
<th>R</th>
<th>T</th>
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<tbody>
<tr>
<td></td>
<td>--</td>
<td>+++</td>
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**Main advantages:**
High accuracy, overcomes the limits of mass selection

**Limits:**
Largely delays the selection decision
Requires a strong organisation and induces high costs

**Conclusion:**
Used only when a high accuracy is necessary (AI males, ...) after a first selection with other methods
Family selection

Average performance of sibs (full- and half-sibs)

<table>
<thead>
<tr>
<th>i</th>
<th>R</th>
<th>T</th>
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<tr>
<td>+/-</td>
<td>+/-</td>
<td>++/-</td>
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Main advantages:
Overcomes the limits of mass selection, with no delay

Limits:
Potential common environment within a family

Conclusion:
Complement to mass selection, species with large families

E. Verrier, Introduction to Animal Breeding, Hanoi, December 2004
**Complementary use of selection methods**

*In practice,* different informations and different selection methods are combined

<table>
<thead>
<tr>
<th></th>
<th><strong>Dairy</strong> AI bulls</th>
<th><strong>Boars</strong></th>
<th><strong>Cocks</strong> Laying hen strains</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pedigree</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td><em>(mating to procreate candidates)</em></td>
<td></td>
<td></td>
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</tr>
<tr>
<td><strong>Own performance</strong></td>
<td>Growth</td>
<td>Growth, Muscle dev\text{(\text{m})}</td>
<td>Growth, Muscle dev\text{(\text{m})}, Egg production</td>
</tr>
<tr>
<td>Sibs</td>
<td>Sexual function</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Offspring</strong> <em>(Progeny testing)</em></td>
<td>Dairy traits, Functional traits</td>
<td>Meat quality</td>
<td></td>
</tr>
</tbody>
</table>

E. Verrier, *Introduction to Animal Breeding*, Hanoi, December 2004
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Summary
Why to select several traits simultaneously

1) Concrete need to improve several traits for a given production

**Meat production:**
- Maternal traits: fertility, litter size, maternal behavior, ...
- Growth, muscle or fat content of the carcass

**Milk production:**
- Dairy traits
- Functional traits: fertility, disease resistance, morphology, longevity

2) Correlated responses, which may be defavourable due to negative correlations between traits
Correlated response to selection

The example of egg production

Average weight of eggs

Total number of eggs

$A_W$

$A_N$

$r_A = -0.4$

Correlated response on $W$

$\Delta G_{(N)}$
Prediction of the correlated response

When selecting on a single trait, one can predict the correlated response on any trait

The correlated is proportional to:

- The genetic correlation between both traits
- The expected genetic progress on the selected trait

\[ E(\Delta G_2|\Delta G_1) = r_{A[1,2]} \frac{\sigma_{A_2}}{\sigma_{A_1}} \Delta G_1 \]
Methods for selecting two traits simultaneously

Independent thresholds

$P = aX + bY$

Linear Index

$P = aX + bY$
Comparison of the two methods

Independent thresholds
  • More easy to apply
  • Allows to make successive cullings
    → it is not necessary to evaluate all candidates for all traits
  • Well suited when the different information are available
    at successive steps in the life of the animals

Linear index
  • More efficient from a genetic point of view
  • Requires that all candidates are evaluated for all traits
  • More difficult to apply and more costly

In both cases: need for a clear hierarchy between traits
  • To fix the different thresholds
  • To fix the weights puted on the different traits
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Summary
Different steps of a selection programme

- Definition of the breeding goals
- Data recording
- Genetic evaluation
- Selection of the reproducing animals
- Use of the reproducing animals

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The use of the reproducing animals

The example of the AI bulls in dairy cattle

- Cows
- Diffusion of $\Delta G$

Bulls' dams → X → Young male calves

- Mass selection
- Progeny testing

Bulls progeny tested → Creation of $\Delta G$

- Culled bulls

Service bulls → Recycling of $\Delta G$

Bulls' sires
Realised genetic gain - dairy cattle in France -

Photos: SOPEXA, UPRA Abondance

Holstein

Montbéliarde

Normande

Abondance

Source: INRA-Institut de l’Elevage

E. Verrier, Introduction to Animal Breeding, Hanoi, December 2004
The use of the reproducing animals

The example of the pig production (from J.P. Bidanel, INRA)

- Selection nucleus
  - D: 100 sows
  - C: 100 sows
  - B: 280 sows
  - A: 280 sows

- Multiplier breeders
  - D x C: 600 sows
  - C x D
  - B x A
  - A x B
  - 2200 boars/year
  - 24000 young sows/year

- Farmers
  - (CD or DC) x (AB or BA)
  - About 50 000 reproducing sows

- Last generation animals (all slaughtered)

E. Verrier, Introduction to Animal Breeding, Hanoi, December 2004
Summary

The efficiency of selection depends on parameters on which some constraints exist.

Interest of combining different selection methods (or different information for genetic evaluation).

It is possible to select simultaneously for several traits.

Using reproducing animals: recycling and diffusion of $\Delta G$.

Usefulness of an organisation of selection.